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ABSTRACT

The reporting of financial statistics for the Higher Education General Information Survey by health professional programs (medical, veterinary, osteopathic, dental, and related programs) was investigated. Attention was directed to how HEGIS data can be used to compare institutions when the mix of programs within the institutions complicates the comparison. The effect of the proportion of first professional programs in the health sciences on instructional expenditures was estimated using regression techniques to analyze data from the 1978 HEGIS survey. This analysis made instructional expenditures in 54 public institutions more comparable. The model included (in order of significance) the number of faculty, the number of full-time-equivalent students, the proportion of first professional degrees in the health sciences awarded by the institution, the average faculty salary, and the amount of noneducation and general expenditures. The proportion of degrees awarded had a significant effect on instructional expenditures. When considered alone, this proportion had almost no predictive value because of the masking effects of differences in size between the institutions. The magnitude of the effect of the proportion of health professional programs should be a concern for researchers.
(Author/SW)

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Working Paper Series

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**Impact of
Health Programs on
Instructional Expenditures
in Higher Education**

**John D. Smith
1982**

HEGIS Data Quality Project

**National Center for Higher Education Management Systems
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Foreword

This report is one of four written as part of the project called Assessing the Quality of the HEGIS Data. The project was supported by the National Institute of Education and was designed to study problems and issues related to the quality of the data collected through the Higher Education General Information Survey (HEGIS) by the National Center for Education Statistics (NCES). There are five major surveys collected annually, and three minor surveys collected periodically. The major surveys are entitled Institutional Characteristics, Financial Statistics, Opening Fall Enrollment, Earned Degrees, and Employees. The periodic surveys are entitled Facilities, Residency and Migration, and Libraries.

Frequently HEGIS data are needed to make comparisons between states, between institutions, and between institutional sectors. Since higher education is so diverse, comparative analysis is often difficult. After reviewing previous work done in the area, this project examined HEGIS data for their comparability, policy relevance, accuracy, and validity. To examine comparability, four studies were conducted through the Data Quality project: (1) the development of a new and improved taxonomy for colleges and universities; (2) a study investigating the impact of medical schools on the financial statistics reported by institutions; (3) a survey of state practices affecting the reporting of HEGIS data; and (4) an assessment of longitudinal changes in the reporting units of the HEGIS universe. To examine policy relevance, the project studied the utility of the data from a researcher's perspective. To examine accuracy and validity, the project conducted a study that suggested NCES could improve the accuracy of the data by more extensive verification checks identifying outlying institutions through cross-survey measures.

Four reports are being made available to any interested party; they are listed below by title and author.

- "An Improved Taxonomy of Postsecondary Institutions" by David J. Makowski and Rolf M. Wulfsberg
- "Impact of Health Programs on Instructional Expenditures in Higher Education" by John D. Smith
- "State Reporting Practices and the Quality of HEGIS Finance Data" by Jane N. Ryland
- "The Utility of HEGIS Finance Data: A Researcher's Perspective" by Marilyn McCoy

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Abstract

Interinstitutional comparison is an increasingly important way to put an individual institution's characteristics and plans into perspective. The quality of such comparisons--their impact on institutional planning and evaluation--depends on factors such as: (1) the accuracy of the data; (2) the use of consistent definitions and data gathering assumptions; and (3) the legitimacy of comparison. Differences in program offerings are thought to confound institutional comparisons. To a large extent, institutions are different because of the different types of programs offered, in terms of level or discipline. This paper shows how HEGIS data can be used to compare institutions when the mix of programs within the institutions complicates that comparison.

The effect of the proportion of first professional programs in the health sciences on instructional expenditures is estimated using robust regression techniques to analyze data from the 1978 HEGIS survey. This analysis makes instructional expenditures in 54 public institutions more comparable. This is regarded as the first such attempt and thus attempts to be inclusive: in future analyses some institutions could be excluded from the analysis and so might some variables. The model includes (in order of significance) the number of faculty, the number of FTE students, the proportion of first professional degrees in the health sciences awarded by the institution, the average faculty salary, and the amount of noneducation and general expenditures.

The proportion of degrees awarded in first professional programs in the health sciences has a significant effect on instructional expenditures. When considered alone, this proportion has almost no predictive value because of the masking effects of differences in size between the institutions in the study. The model was constructed so as to describe the behavior of the institutions as efficiently as possible. The stability and simplicity of the relationships described by the regression model suggest that more measurement in this area is needed. Researchers should be warned about the magnitude of the effect of the proportion of health professional programs.

Introduction

The Data Quality Assessment project is a step toward broader dissemination and utility of the HEGIS data. Thus it is part of a continuing effort over the past decade that has included various NCHEMS efforts to make institutional data more comparable by standardizing categories and definitions used to describe programs, finances, and facilities. This effort will be followed by projects to make the HEGIS data more useful and accessible to the institutions that provide the information for their own planning, budgeting, and analysis. Aside from characterizing the field as a whole, the most promising use of HEGIS data is for inter-institutional comparisons, placing institutional detail against a larger background. This requires data quality assessment at both aggregate and institutional levels and brings issues of institutional comparability immediately to the fore. Comparison of complex institutions is difficult in any case and comparisons using HEGIS data have their own specific kinds of challenges.

The difference between institutions with no first professional programs in the health sciences (hereafter referred to as health professional programs) and institutions with such programs in this area has been pointed out before (McCoy and Halstead 1979) and will be treated in the new study (McCoy and Halstead forthcoming) by separately reporting statistics for each type of institution. The difference in cost per student between the different types of institutions is shown in table 1. Schools that are primarily devoted to medical education show a much higher instructional cost per student than the other types of institutions. The presence of medical programs seems to make a difference in comparison with the other types of institutions (such as major research and other doctoral).

Table 1

1978 Average Instructional Expenditures per FTE Student

Institutional type	Public	Private
Medical Schools	13,615	8,594
Major Research		
With medical programs	2,713	4,641
Without medical programs	2,011	4,313
Other Doctoral		
With medical programs	2,448	3,464
Without medical programs	1,939	2,006

Note: This table uses medical programs (MD, DDS, DVM, and OD) as the criterion for classification. In the rest of this paper a more inclusive category of health professional programs is used.

There are a number of factors that contribute to this difference, including high faculty salaries, expensive facilities, and all of the other factors that are associated with the high cost of our health care delivery system. These high costs have a significant impact where present within higher

education. This clear-cut distinction between institutions primarily devoted to health professional programs and those devoted to other kinds of programs, however, becomes complicated when both kinds of programs are present on the same campus. Institutions, not programs, are the reporting unit in the HEGIS survey, and health professional programs have a varying impact according to their size and the size of the institution whose statistics they confound. Does the high cost of instruction in the health professional programs, therefore, prevent comparisons between institutions by affecting total instructional expenditures to a large but unknown extent? What strategy could be used to make institutions having both health professional programs and other presumably less expensive programs more comparable to each other? This paper attempts to answer these questions. A related question (which is not answerable at this point) is whether the effect of health professional programs can be distinguished from the effect of an emphasis on research, or, for example, on engineering or other high cost programs, on graduate instruction, or on other factors?

When a factor such as the proportion of health professional programs has an unknown effect on total instructional expenditures, the difficulty of comparing institutions can have a number of consequences:

- It reduces the reliability and meaningfulness of broad measures, summaries, and analyses of the field as a whole
- It complicates discussions where legislators or others with oversight responsibility want to look at "cost differences not otherwise accounted for," particularly when an individual institution is being examined closely
- The factor is simply ignored and the use of outlier analysis (for instance, to check data quality routinely) is much less effective than it might be if the effect of this factor were known

Can the HEGIS survey be used to estimate instructional expenditures by type of program so that comparison can be made correcting for programmatic differences? The ideal, of course, would be to give data users the freedom to choose the unit of aggregation for the purpose at hand when analyzing HEGIS data: student, program, institution, system, geographical area, set of peers, or institutional sector. But without complete flexibility in the unit of analysis it is still possible to estimate the effect of different programs with existing data.

This study is thus a first attempt to estimate what will no doubt be estimated for a variety of purposes in the future. It is obviously less satisfying to estimate effects indirectly than it would be to measure them directly, and the present estimate suggests the importance of efforts to make more direct measurements. As a first pass of the data it was decided to include all possible institutions in the study (including institutions awarding MD, DDS, DOS, DVM, and related degrees). A wide ranging group of variables were considered. Choices between variables to keep in the final equation also reflected the fact that this is the first of a possible series of analyses: efficiency and stability of the estimates had to be balanced with their policy relevance. With the present over-all study as foundation, further analyses of selected institutions, degrees, and variables are more clearly warranted and will hopefully be more easily carried out.

The idea of developing a meaningful estimate of the effect of health professional programs that would be statistically sound faced the following problems:

- No theory of higher education was suitable for derivation of the appropriate relationships to be estimated.
- Many of the chosen variables had distributions that were highly skewed--with a few institutions far larger than the rest.
- Uncertain relationships existed although the NCHEMS taxonomy clearly had separated institutions into meaningful groups. It was not certain beforehand what relationship those categories had with the problem under study since institutions with both health professional and other programs occurred in 3 different classifications.
- Many variables were available for inclusion in the model and it quickly became evident that the collinearity that many of these variables exhibited would have a substantial effect on the selection of the final variables.
- The relationship between instructional expenditures and the proportion of health professional programs is masked by the effects of other variables. The regression of the proportion on instructional expenditures (with no other variables in the equation) has an R-squared of .0002 for the public institutions, meaning that it has almost no predictive value by itself.

This paper uses robust regression techniques to estimate the effect of the proportion of health professional programs on instructional expenditures. The resulting estimates can be useful in several ways: to compare how institutions differ from the model that best describes a group of institutions (either to check for bad data or to elicit discussion of the specific differences between institutions); to look at an individual institution within the framework of a model that describes a set of peers; to estimate the overall effect of the proportion of health professional programs; and to assess the stability and strength of systematic variation.

Description of the Data

The data set for this study was constructed from the HEGIS Finance, Opening Fall Enrollments, Earned Degrees, and Employees surveys of 1978. The institutions selected for this study included all reporting institutions that have health professional programs and that were classified by the NCHEMS taxonomy as major doctorals and comprehensive institutions (see Makowski and Kulfsburg 1980)--essentially all graduate institutions excluding the specialized schools. Health professional was defined broadly to include medical, veterinary, osteopathic, dental and related programs. Ninety-one institutions had such programs, as shown in table 2.

Table 2

Classification of Institutions in the study

NCHEMS Taxonomy	Control	
	Public	Private
Major Research	34	19
Major Doctoral	16	12
Comprehensive	4	6

In selecting the variables for the regression model it was necessary to resolve several issues such as:

- Conflicts between statistical stability and ease of interpretation
- Problems of collinearity and overall efficiency

Initially, a large number of variables were selected for inclusion in the model but were reduced to 5 predictor variables after thorough exploratory analysis. Variables originally considered included graduate and undergraduate FTE students; tenured and untenured faculty headcount; program counts at various levels; counts of degrees in the different disciplines; revenues from appropriations, grants, tuition, and other sources; and expenditures for research, public service, and various kinds of independent operations.

A heuristic model was used as a guide in the selection of the original variables and in the decision to combine or eliminate them. Although it proved useful as a guide, it is provocative but perhaps ambiguous:

Instructional expenditures are related to products (or outcomes related to an institution's mission) and conditions (or internal features of the institution).

An example of this conceptual model's ambiguity is that student FTE can be regarded as either product or as condition. Student FTE measures the product of an institution by measuring credit hour production. At the same time, student FTE is a primary measure of size--a condition that affects most other internal features of an institution to a great extent. Table 3 lists the variables that were used in the final regression analysis.

Table 3

Variables Selected for the Model

Variable		Reexpression
\$ Instr	Instructional expenditures (education and general)	logarithms
Students	Full time equivalent students	square roots
Faculty	Faculty headcount	square roots
Facsal	Mean faculty salary	none
Non-E&G	Noneducation and general expenditures	logarithms
Prof-Prop	Proportion of degrees conferred in first professional programs in health sciences	folded logs

Instructional expenditures was the dependent variable. Full Time Equivalent students was regarded as measuring the size of the institutions. Faculty headcount was thought of as a measure of both the size of the faculty and of the size of the administrative and other staff that directly supports it. Average faculty salaries was a condition of central importance to the institutions under study. Noneducation and general expenditures reflected noninstructional activity at an institution. And, finally, the proportion of health professional degrees was a measure of program emphasis of central importance to the study.

Table 3 also shows the reexpression that was used to make the variables more symmetrically distributed. It was necessary to reexpress almost all of the variables used in the study. (See discussions in Tukey 1977 and Mosteller and Tukey 1977, regarding methods and effects of reexpression.) Reexpression is important because without it, severely skewed distributions allow the largest observations to play a disproportionate role in the calculation of a regression parameter as well as error estimates. Badly skewed data inflate confidence intervals unrealistically. An alternative to reexpression would be to throw out observations, which is often arbitrary and wasteful. In some cases reexpression serves to linearize parameters that would otherwise be nonlinear and thus could not be estimated by conventional least-squares computer programs. The reexpression of proportions, for example, which is recommended by Snedecor and Cochran 1967 (p. 497-507) as well as others, is based on the idea that a 1 percent change between 51 percent and 52 percent is almost always less significant than a 1 percent change between 97 percent and 98 percent. Reexpression as folded logs allows the measurement of proportion (not absolute size of programs) with units that are linear as program size doubles. The price paid is that results require a little more effort to describe or interpret.

Exploratory analysis and discussion determined that separate regressions would be run for privately and publicly controlled institutions. The differences in financial patterns and operating styles were thought to influence significantly most of the variables in the study. This influence was so pronounced that the regression model that was developed turned out to be rather unstable for the private institutions although it was quite good for the public institutions. The difference between the two, from the perspective of model building, was greater than was anticipated.

Discussion

A variety of fitting techniques were used in the course of this analysis. Many of the exploratory fits were done using stepwise ordinary least squares and iteratively reweighted least squares. Since reexpression corrected the problems with outliers, it was possible to use a Jackknife regression to estimate both parameters and confidence intervals for the parameters (Mosteller and Tukey 1977). Jackknife regression gives insight into the effect of individual observations on the model as a whole.

What is most striking about the final regression analysis is the difference between the public and private institutions. The R-square for the private institutions (.823) was not as high, although the parameters were quite near those estimated for the public institutions. Jackknife regression showed all these parameters to be considerably more unstable (that is, fluctuating significantly depending on the inclusion of individual institutions) and the proportion of health professions did not contribute significantly to the overall R-square. Therefore the parameter estimates for the private institutions are not reported here. Further study is necessary to develop a better model for their behavior.

Several possible explanations for this failure suggest themselves, although conclusive statements obviously cannot be made until a satisfactory model has been constructed. Perhaps the original idea for the study was somewhat biased toward "rationally" funded institutions. Formula funding of public institutions perhaps makes funding consistent and comparable if not necessarily rational by tying it to FTE students, for example. Perhaps the conceptual scheme that was used to construct the model needs another term (which would actually apply to both public and private institutions, but is not currently available in HEGIS data) that would measure "support from the environment." Alumni giving and size of endowment would be obvious candidates for the private institutions while relationship with the appropriate legislative body would be a possibility for the public institutions. The local consumer price index would be also a logical candidate for possible inclusion.

The final regression equation is shown in table 4.

Table 4
The Regression Coefficients and Confidence Intervals

Variable	Estimate	Confidence Interval	Percent of Variance
Intercept	5.378	.982	
FTE Students	.00242	.00257	10
Faculty headcount	.0430	.0309	41
Faculty-squared	-.000453	.000416	26
Avg Faculty Sal	.0000159	.00000966	8
Non-E&G Expend	.149	.151	7
Prof-Prop	.193	.1180	8

Confidence Interval is the 95 percent confidence interval, based on a two-sided T-test. The variables are reexpressed as described in table 3.

The R-square for the fit to public institutions is .9073. The confidence intervals show the stability of the estimates--that is, individual institutions do not influence these estimates too much. The percent of variance attributable to each variable makes sense. Students and faculty account for the greatest amount of variance because they are the primary measures of size. The proportion of health professional degrees accounts for slightly more variance than average faculty salary. The proportion of health professional programs improves the R-square by .0844, which is significant at $p = .001$.

Figure 1 translates the effect of the proportion of health professional programs on instructional expenditures in public institutions from the linear relation in folded logs to a non-linear one in percents. Although instructional expenditures actually range from \$7 million to \$134 million, the graph only shows the possible variance attributed by the model to the proportion of health professional programs for a middle-sized institution. For an institution with a small proportion of health professional programs, a rather small change in the size of these programs can significantly affect instructional expenditures. Institutions with a larger proportion of health professional programs are less sensitive to a small change in this proportion.

In the present context folded logs are better than percents because:

- Percents are inevitably interpreted in terms of zero and one hundred percent--which are not meaningful in the present context since these extremes are deliberately not included in the study and the parameter estimates should not be extrapolated to these extremes. Folded logs are more naturally interpreted in relation to the half-and-half point.
- Regression techniques do not handle truncated distributions well (for example, the fact that it could not have been more than 100 percent in this context makes it a truncated distribution).
- Folded logs make more intuitive sense when interest focuses on the change in proportion rather than the proportion itself, as illustrated in table 5.

Table 5

Comparison of Folded Logs to Percents

Difference	4	8	16	
Percent	4.	8.	16.	32.
Number of Students	40	80	160	320
Folded log	-1.61	-1.26	-.91	-.56
Difference	.35	.35	.35	

This table shows a set of proportions (say of health professional students in schools with 1,000 students total) expressed both as percents and as folded logs. To show the effect of change, the count of students has been doubled 3 times (any other constant increase would have the same relative effect on percents and folded logs). The differences are constant in folded logs, which is what we want in many cases.

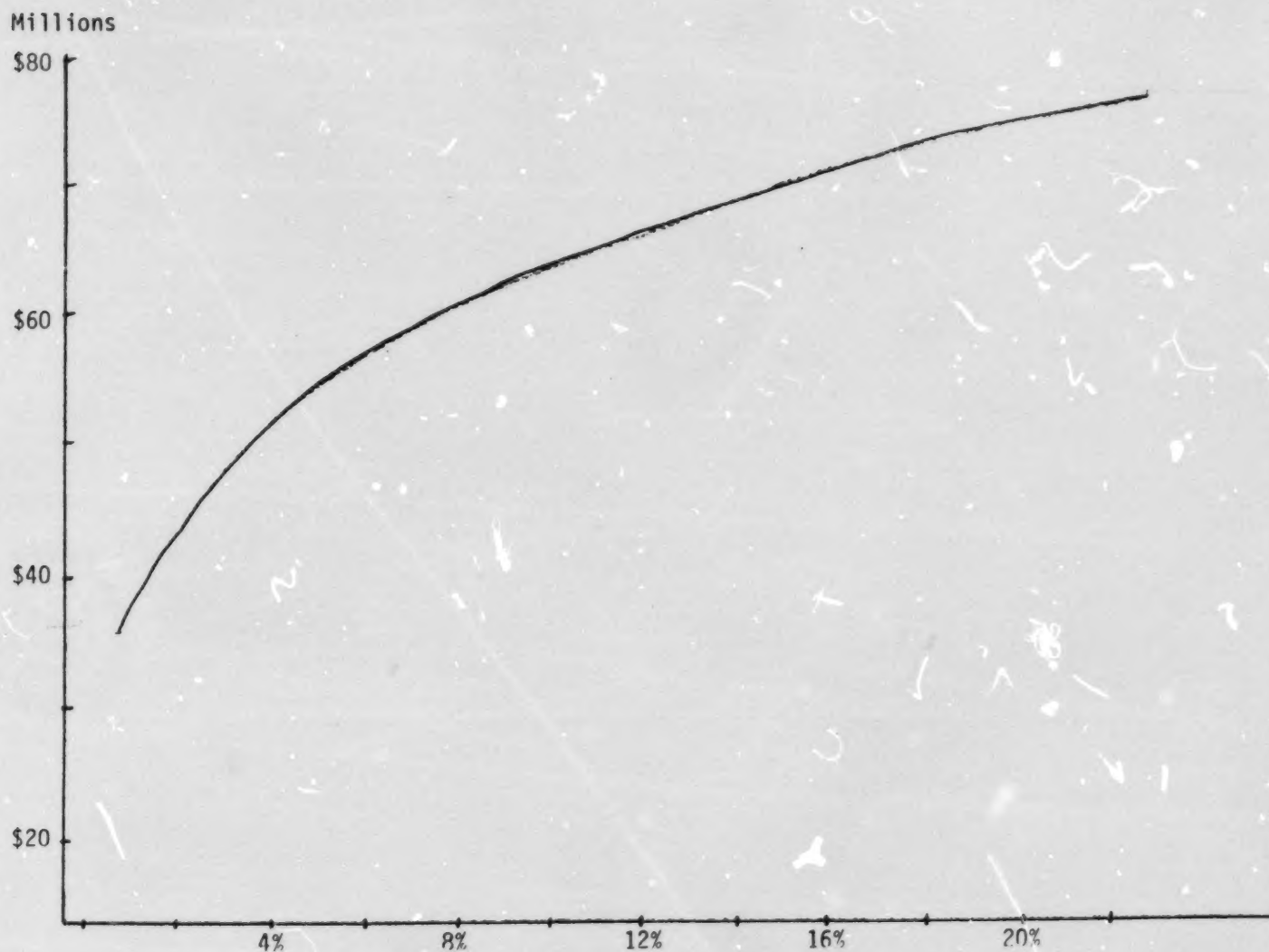


Fig. 1. Instructional Expenditures and Percent Health Professionals - 54 Public Institutions

The residuals from the analysis are as important as the regression equation itself since interest is both in what is systematic about these institutions as well as in what appears not to be. In an analytic paper such as this, the systematic aspect is usually discussed at greater length, but in making inter-institutional comparisons, frequently the goal is to compare residuals; that is, differences between institutions not otherwise accounted for. Table 6 shows the largest residuals of the model described in this paper, expressed in standard deviations. There may be some remaining structure (or systematic error) in these residuals--as suggested by the fact that the model predicts smaller instructional expenditures than observed for these 3 midwestern institutions and that it predicts greater expenditures than observed in the other institutions. If we are satisfied with this model, it is possible to make statements such as "Colorado State University and the University of New Mexico have instructional expenditures that are almost two standard deviations below the average, other things being equal." In terms of a discussion of a large group of institutions this may not be of much interest, but to these individual institutions this may be quite significant and useful. Discussion might then focus on historical or other peculiarities and on the implications of this difference for the future.

Table 6

Listing of Institutions with the Largest Residuals

Resid	State	Institution
2.2	MI	Wayne State University
1.8	IL	Southern Illinois University at Carbondale
1.8	IN	Purdue University
-1.7	CO	Colorado State University
-1.8	NM	University of New Mexico Main Campus
-1.8	WV	West Virginia University
-1.9	VA	University of Virginia Main Campus

Conclusion

The regression equation that has been developed for the public institutions is stable and accounts for a substantial proportion of the total variance. The regression analysis has brought greater order to the data in terms of our sensitivity to outliers, for example. The failure of the model for private institutions is disappointing but probably of some interest in itself. Perhaps funding for instruction in public institutions is determined more "rationally"--funding for privates probably depends a great deal more on marketplace factors such as endowment income that was not considered as a candidate in the model building process.

This kind of regression equation can be used for several purposes, such as:

- Attribution of a part of instructional expenditures to the proportion of degrees can be made. Whether or not to report statistics for such institutions separately depends on the purpose at hand and the complexity the analyst is willing to bear. For detailed analysis--especially when comparing institutions to each other--the proportion of degrees should be considered when making comparisons. For more aggregate reports or analyses, the proportion of health professionals should be given some appropriate weight.
- Emphasizing the differences between institutions ceteris paribus: Instruction at University of Virginia costs a great deal less, other things being equal, than instruction at Wayne State University. The regression model is what allows the expression: "other things being equal," and says by how much.

Suggestions for Further Study

Several directions for further investigation have emerged in the course of this study and are briefly described below.

- The regression analysis could be extended to include institutions with no first professional programs in the health sciences (which are nevertheless similar along other dimensions) and also institutions that are almost completely devoted to programs in this area. Such a study could both extend the investigation and verify the methods and estimates in a larger context.
- The methodology used in this study could be applied to other kinds of programs with costs known to be particularly high or low. Engineering and natural sciences might be examples of the former, with English and philosophy as examples of the latter.
- Public service or research expenditures could be investigated with the same methods used in this study. Exploratory analysis suggests that building a good model would be somewhat more difficult. There is some question as to whether the HEGIS data on public service research activities and related variables is enough to provide a basis for a model that predicts their behavior.
- Exploratory analysis of the distributions of variable such as expenditures and number of degrees in a variety of categories suggests that further work could be of use in this area. Stretching or truncations of the tails of these distributions could characterize how concentrated or dispersed an activity is in a group of institutions or what the minima or maxima for the field as a whole might be. A data users' guide to the HEGIS data might point out such distributional peculiarities.

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